SYNTHESIS, CHARACTERIZATION AND RADIATION INDUCED EFFECT ON GRAPHENE

A Synopsis of the Thesis submitted to the Mangalore University
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Final Synopsis of the PhD Thesis

Introduction

Graphene is pure carbon in the form of a very thin, nearly transparent sheet and one atom thick. It is remarkably strong, for its very low weight and it conducts heat and electricity with great efficiency. While scientists had theorized about graphene for decades, it was first produced in the lab in 2004. Because it is virtually two-dimensional, it interacts oddly with light and with other materials. Graphene is a crystalline allotrope of carbon with 2 dimensional properties which plays an important role since it is the basis for the understanding of the electronic properties in other allotropes. In graphene, carbon atoms are densely packed in a regular sp^2-bonded atomic scale (hexagonal) pattern. Graphene can be described as a one-atom thick layer of graphite. Graphene research has expanded quickly since the substance was first isolated in 2004. Research was informed by theoretical descriptions of graphene's composition, structure and properties, which had all been calculated decades earlier. High quality graphene also proved to be surprisingly easy to isolate, making more research possible. Andre Geim and Konstantin Novoselov at the University of Manchester won the Nobel Prize in Physics in 2010 for their ground breaking experiments regarding the two-dimensional material graphene.

Graphene has a number of properties, which makes it interesting for several different applications. It is the thinnest, mechanically very strong, transparent and flexible

conductor. The electron mobility of the graphene is very high at room temperature which makes this material very interesting for electronic and high frequency applications such as high frequency transistor and modulator. Two-dimensional graphene has specially attracted a lot of attention because of the quantum Hall effect at the room temperature and the ambipolar electric field effect along with ballistic conduction of charge carriers. Some other properties of graphene that are equally interesting includes, its unexpectedly high absorption of white light, high elasticity, unusual magnetic properties, high surface area, gas adsorption and charge-transfer interactions with molecules. Since graphene is the transparent electrode, it may be widely used in the liquid crystal display (LCD), organic light-emitting display (OLED), where it can replace the rather fragile and expensive indium–tin–oxide (ITO). Established on large specific surface area, graphene is also used in the gas detectors and biosensors. Besides, new types of composite materials based on graphene with great strength and low weight also become interesting for use in satellites and aircraft. Applications of graphene are extensive in electronics, photonics, sensing and also in the field of energy generation and storage.

Aim and Scope

Graphene-based nanomaterials have attracted considerable interest in recent years owing to their applications in medicine, biotechnology, and various interdisciplinary sciences. The literature review indicates new potential applications of graphene and its dérivatives to anticipate more emphasis on the research with these novel materials. In view of this the

systematic investigations were carried on the synthesis of graphene from graphite flake and characterization studies on and antic cancer property

The specific objectives of the investigations are as follows:

- Synthesize graphene oxide using effective modified Hummer's method and chemically reduces it to reduced graphene oxide.
- Investigation of the synthesized graphene oxide and reduced graphene oxide on some fundamental properties using various characterization techniques.
- Study the electrical properties of synthesized graphene oxide and reduced graphene oxide in pellet form.
- Synthesize ZnO-G nanocomposite by simple ultrasonication method and to study the modification in the fundamental properties.
- Synthesize graphene quantum dots by simple pyrolysis method and to study the modification of morphological and photoluminescence properties subjected gamma irradiation.
- A detailed investigation of the cytotoxicity of the different nanomaterials that were synthesized and modified.

Methodology

- Graphene oxide was synthesized by Hummers' method from graphite flakes.

- The chemicals used for synthesis are Graphite powder, Sulfuric acid (H2S04, 98%), potassium per manganite (KMnO4, 99.9%), hydrogen peroxide (H2O2 30%). Graphene/Zinc oxide nano composite were synthesized using chemical method.
- The thermal analysis were carried out using TGA/DTA analysis.
- The structural characterization of nanomaterials is very important as it helps to understand the internal structure and morphology of the material at different angles. Different analytical techniques used in the present work are XRD, FTIR, Raman spectroscopy, SEM, TEM and EDX.
- The synthesized nanomaterials were optically characterized by UV-Visible absorption spectroscopy and photoluminescence spectroscopy.
- For the synthesis of this nano composite zinc acetate dihydrate as starting material along with previously synthesized graphene oxide
- Gamma irradiation was carried out for surface modification.
- Anticancer properties studies were carried out using MTT assay

The Thesis

- The thesis is comprised of seven chapters. A general introduction to the present investigations is given in the first chapter, in which a brief discussion about carbon nanomaterials, graphene, graphene oxide, reduced graphene, synthesis, properties, and their applications was discussed. In addition, the graphene quantum dots, synthesis, surface modification properties application, and effect of gamma

irradiation were discussed. Moreover, scientific background with a detailed survey of the literature is presented. The scope and objectives of the present work are also outlined in this chapter.

- The second chapter deals with the details of the experimental methods and techniques used in the study. The technical details of all the methods using which the synthesized samples were characterized viz. thermogravimetric (TG) analysis and Differential scanning calorimetry (DSC), powder X-ray diffraction (XRD), Fourier transforms infrared (FTIR), Raman spectroscopy, scanning electron microscopy (SEM), transmission electron microscopy (TEM), energy dispersive X-ray analysis (EDX), UV-visible and photoluminescence (PL) spectroscopy. The cell culture techniques for cell lines for cancer cells were explained. The results obtained in the present systematic study are analyzed and discussed in the third to fifth chapters.

- The third chapter entails the studies pertaining to the synthesis and characterization of graphene oxide (GO) and reduced graphene oxide (RGO). The graphene oxide is synthesized by the efficient Hummer's method and also synthesized reduced graphene oxide by chemical reduction method. Synthesized GO and RGO were characterized using different characterization techniques. Also, electrical characterization was carried out with a novel method; pellet form.

- The fourth chapter provides a detailed discussion about the graphene nanocomposite. The zinc oxide graphene (ZnO-G) nanocomposite was

synthesized by a simple ultrasonication method. Characterizations were carried out for a detailed study of different properties.

- The fifth chapter provides a detailed investigation of graphene quantum dots (GQDs). GQDs were synthesized by the pyrolysis method and characterizations were carried out. Also, surface modifications were done using different doses of gamma irradiation.

- The sixth chapter includes the cytotoxicity studies of graphite, graphene oxide, reduced graphene oxide, ZnO-G nanocomposite, graphene quantum dots, and finally with gamma-irradiated graphene quantum dots.

- Important conclusions drawn from the present investigations are summarized in Chapter 7. Scope for future studies in this field is also presented at the end of this concluding chapter.

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Research Guide Research Student

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LIST OF PUBLICATIONS

Journals

1. Poornima U S and Narayana Y, "Studies on synthesis, Optical and Thermal properties of Graphene Oxide", *International Journal of Advanced Scientific and Technical Research*, ISSN 2249-9954,Vol.5, Issue 5, 2015.
2. Poornima U S and Narayana Y, "Synthesis and structural characterization of graphene", *Nano and Material Science*, ISBN 978-93-85682-09-4, Vol.1, 2015
3. Poornima U S and Narayana Y, "Structural investigation of chemically synthesized graphene nanocomposite", *Recent Advances in Materials Science and Biophysics*, ISBN 978-93-5291-953-6, Vol.1, 2018.
4. Poornima U S and Narayana Y, "Study of morphological and photoluminescence properties of graphene quantum dots subjected to gamma irradiation", I*ndian journal of pure and applied physics*, article id IJPAP-6601 (communicated).
5. Poornima U S and Narayana Y, "Synthesis and characterisation of graphene oxide and reduced graphene oxide", *Journal of Advanced Science, Engineering and Medicine* (communicated).
6. Poornima U S and Narayana Y, "Study of Zno decorated graphene nano composite" *Journal of Basic and Applied Physics",* paper no: IJEE10501 (communicated)

7. Poornima U S and Narayana Y, "Electrical characterization of graphene oxide and reduced graphene oxide", *Indian Journal of Physics* (communicated).

8. Poornima U S and Narayana Y, "Studies on cytotoxicity of carbon nonmaterial and based", *Ecotoxicology and Environmental Safety*, Elsevier (Communicated).

Conference

1. Poornima U S and Narayana Y, " Effect of Graphene Oxide on the Structure and Properties of Poly(vinyl alcohol) Composite Films" National conference on Particles Accelerators in Interdisciplinary Research, Mangalore University, April 11-13, 2017.
2. Poornima U S and Narayana Y "Synthesis and Enhanced thermal stability of PVA/GO Nano composite" Two day National conference on Reaching the Unreached through Science and Technology: Recent Advances in Physical, Chemical, Mathematical and Biological Science for Energy, Health and Environment, Mangalore University, September 8-9.2017.
3. Poornima U S and Narayana Y "Synthesis and structural characterization of graphene–zincoxide nanocomposite", National conferencde on Recent Trends in Applied Science & Technology held at Alliance College of Engineering & Design, October 26-27, 2017.

Workshops

1. National Conference on Condensed Matter Physics and Application conducted by department of physics, MIT, Manipal University, Manipal, March 27-28, 2015.
2. National seminar on Research aspirants of Nano Materials and is Application organized by the Department of Physics, BGSR&D Centre, SJC Institute of Technology, July 21-22, 2015.

3. Workshop on Radiation and its application in Physical, Chemical and Life Sciences organized by Department of Physics, Mangalore University and UGC-DAE Consortium for Scientific Research Kolkata Centre, June 24-25, 2015.
4. INUP Familiarization Workshop on Nano Fabrication Technologies, IIT Bombay, Mumbai, December 16-18,2015
5. National Conference on Nano and Material Sciences held at Dayanada Sagar University, Bangalore, December 21, 2015.
6. National seminar on Inter-disciplinary research: Challenges and opportunities, Association of British Scholars, Mangalore Chapter. Mangalore University, October18, 2016.
7. National seminar on Emerging Solar PV Technology Application for Academics, Mangalore University, December 3, 2016.
8. Science Academies Lecture workshop on Condensed and Soft Matter Physics, Mangalore University, February 22-24, 2017.

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